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Report on the mammals of Quimsacocha National Recreation Area, Azuay Province, Ecuador

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Abstract

Quimsacocha National Recreation Area is located on the western slope of the Andes in Azuay Province, southern Ecuador. All sampling locations were in the high paramo and high Andean forests (3,572 to 3,865 m). The habitats include paramo, bogs, riparian, patches of elfin forests, and secondary cloud forest. We set Sherman, pitfall, and camera traps (3,600 trap nights), and mist nets to collect 117 specimens. Eight species were collected, including *Caenolestes caniventer* Anthony 1921; *Didelphis pernigra* J.A. Allen, 1900; *Cryptotis montivagus* (Anthony, 1921); *Akodon mollis* Thomas, 1894; *Microryzomys altissimus* (Osgood, 1933), *Phyllotis haggardi* Thomas, 1908; *Sigmodon inopinatus* Anthony, 1924; and *Sylvilagus andinus* (Thomas, 1897). Two additional species *Coendou rufescens* (Gray, 1865) and *Odocoileus virginianus* (Zimmermann, 1780) were documented photographically. This is the first survey that saved voucher specimens for mammals of Quimsacocha.

Keywords

High Andean paramo, *Polylepis* forests, mammal survey

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Introduction

The Quimsacocha National Recreation Area is located in the high Andes of southern Ecuador. Quimsacocha is 3,217 ha in area and from 3000 to almost 4,000 m in elevation. This area is considered the nucleus of the Cajas Massif Biosphere Reserve. To our knowledge, this is the first survey for mammals of Quimsacocha with documented voucher specimens. Romo et al. (2018) listed eight species in an Ecuadorean government publication: *Akodon mollis* Thomas, 1894; *Phyllotis haggardi* Thomas, 1908; *Phyllotis andium* Thomas, 1912; *Microryzomys altissimus* (Osgood, 1933); *Sylvilagus andinus* (Thomas, 1897); *Lycalopex* (*Pseudalopex*) *culpaeus* (Molina, 1782); *Odocoileus virginianus* (Zimmermann, 1780); and *Conepatus semistratus* Boddaert, 1785. However, there is no information on voucher specimens or where they are deposited, and no exact locations were cited for those specimens. Nineteen species of mammals were recorded from neighboring Cajas National

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Park (Barnett 1999). Nine of those species were found in the paramo of Cajas or in similar habitat to this study. These include: *C. montivaga* (*montivagus*), *A. mollis*, *Chicbchanomys orcesi*, *M. altissimus*, *Phyllotis andium*, *P. haggardi*, *S. inopinatus*, *Thomasomys pyrrhonotus* (*auricularis*), and *T. gracilis* (*hudsoni*) (Barnett 1999).

The habitat in our study area was mainly paramo with a few very small patches of elfin or *Polylepis* forest. The understory of the *Polylepis* forests was predominately ferns with a thick mat of mosses. The paramo is dominated by grasses; the most common is a bunch grass *Stipa ichu* (Ruiz & Pav.) Kunth (Patzelt 2004). Poorly drained areas contained large mats of *Plantago rigida* Kunth. Some areas were planted with introduced pines.

Geologically, Quimsacocha was formed in the Pliocene and Pleistocene and is composed of two geologic formations. The Turi formation contains rhyodacitic and pyroclastic lavas and the Tarqui formation has congloms, tuffs, and breccia (Longo and Baldock 1982).

The purpose of this study was to document the small mammal assemblage and to compare the results with other studies (Fig. 1). This helps to document a complete assemblage of the mammals as possible.

Methods

Sampling was conducted from 23 July to 9 August 2018 at the Quimsacocha National Recreation Area, Azuay Province, Ecuador (the central location is 03°03′15″S, 079°13′41″W Fig. 1). Quimsacocha is part of the Herbaceous Paramo ecosystem (Sierra et al. 1999). The total area of the park is 3,217 ha (Romo et al. 2018). The

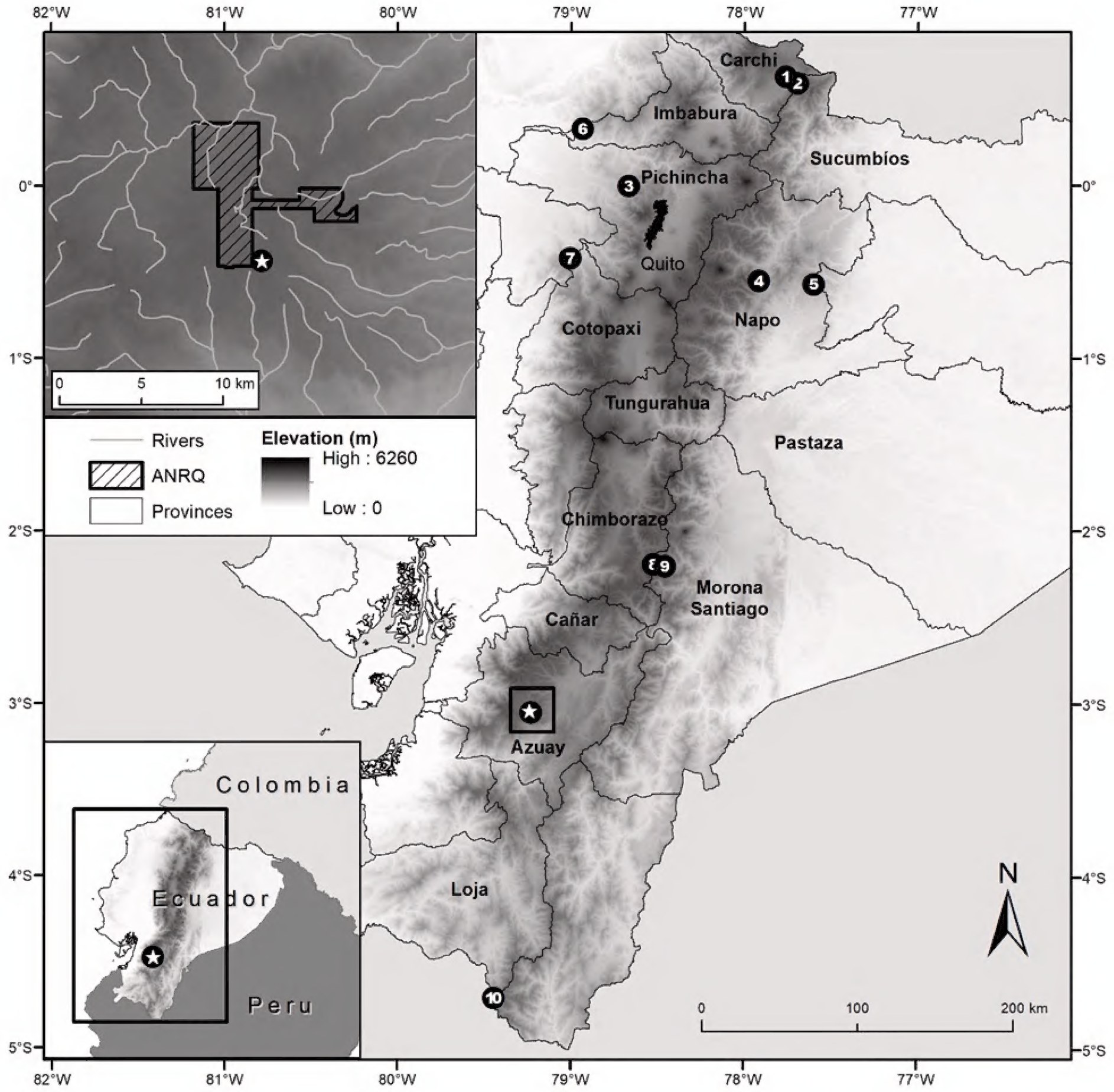

Figure 1. Map of our survey sites and provinces in Ecuador. ★ = Area Nacional de Recreación Quimsacocha, Azuay. 1, 2 = Guandera Biological Reserve, Carchi; 3 = Tandayapa, Pichincha; 4 = Cosanga, Napo; 5 = Volcán Sumaco, Napo; 6 = Santa Rosa, Imbabura; 7 = Otonga, Cotopaxi; 8, 9 = Parque Nacional Sangay; Chimborazo; 10 = Parque Nacional Yacuri, Loja.

lowest point of sampling was 3,572 m, and the highest was 3,865 m.

The average temperature depends on elevation. However, the average for the park is about 8° C, with maximums that rarely exceed 20° C and lows near 0° C. The rainfall is between 1,000 and 2,000 mm, depending on the elevation and the direction of slope (Romo et al. 2018). Most of the habitat above 3,700 m is paramo or alpine grassland. Only two patches of high elevation *Polylepis* forests were found, each less than 1 ha in area. Within the Quimsacocha paramo there are small ponds, lakes (lagoons), and bogs covering a total area of 30.8 ha. The mountain streams that we encountered above 3,700 m in elevation were less than 1 m wide.

We set 200 Sherman traps, each trapping session for 3,600 trap nights, baited with a mixture of peanut butter, oats, banana, and vanilla extract. We used eight transects set in different habitats including about 50% in paramo, streams, stream banks, and 50% in patches of forest. Two transects of 10 pitfall traps were set by streams and marshes in the paramo. Four Tomahawk traps were located in forested habitats. Four 9-m mist nets were set in the temperate evergreen forest across a stream at 3,572 m.

We were able to set 10 Browning Strike Force (model BTC-5HDE) trail cameras in forested habitats located at 3,791 m and 3,572 m. Digital images were taken with a Canon 5D Mark III camera of all the species recorded (Fig. 2).

We discovered about 20 owl pellets by searching the base of deep cliff overhangs and shallow caves. These cliffs were located at 03°03′31″S, 079°13′06″W at 3,762 m in elevation. From these, we recovered skulls and skeletons of small mammals.

For some specimens, the DNA was extracted from heart, liver, and kidney tissue collected in the field, using the Bilton and Jaarola (1996) protocol from samples preserved in 90% ethanol. The mitochondrial gene (Cytb) was amplified by primers MVZ05 and MVZ14, using the protocol of Smith and Patton (1992). The sequences were assembled and edited in the Geneious R11 program (https://www.geneious.com) and for the phylogenetic reconstruction we used Genbank sequences (Table 1). The evolution model (GTR) was obtained through PartitionFinder v. 1.1 (Lanfear et al. 2012), and a phylogenetic reconstruction was performed based on maximum likelihood in the RAXML program (Stamatakis 2014).

All 117 voucher specimens (skins, skulls, skeletons, and frozen liver tissue) were deposited in either the Abilene Christian University Natural History Collection (ACUNHC) or the Sección Mastozoología, Museo de Zoología at Pontificia Universidad Católica del Ecuador (QCAZ-M). The guidelines for the treatment of wild animals in research as stated by the American Society of Mammalogists (Sikes et al. 2016) were followed. The field trip was conducted under the legal authorization of the Ministerio del Ambiente (license number 011-2018-IC-FAU-DNB/MA).

Results

We recorded 10 species belonging to six orders and seven families of mammals. The taxonomic order below follows Tirira (2017).

DIDELPHIMORPHIA
Family Didelphidae

***Didelphis pernigra* J. A. Allen, 1900**

Material captured. One female (QCAZ 17946), measurements (in mm): total 864, ear 52, foot 77; 03°05′36″S, 079°13′35″W; elevation 3,572 m; 31 July 2018; collectors: Lee, Tinoco and Crockett; caught in a Tomahawk trap in mountain cloud forest.

Identification. The head is white with a black longitudinal stripe in the middle of the forehead. The ears are white with a black base, and there are black marks around the eyes. The dorsal fur is black (Fig. 2B). The distinctive white and black markings on the head easily distinguish this species from other sympatric didelphids (Astúa 2015; Tirira 2017).

PAUCITUBERCULATA
Family Caenolestidae

***Caenolestes caniventer* Anthony, 1921**

Material captured. One female (QCAZ 17851), measurements (in mm): total 230, ear 14, foot 24; 03°05′37″S, 079°13′38″W; elevation 3,572 m; 4 August 2018; collectors: Lee, Tinoco and Crockett. This specimen was collected in a Sherman trap by a roadside stream.

Identification. Our specimen shows clear countershading of the species (Patterson 2015; Tirira 2017). The dorsal fur is a dark grayish brown (Fig. 2A). The ventral fur is whitish or cream colored. The tail is bicolored (Tirira 2017). The antorbital vacuity is comma-shaped opening bordered by the frontal, maxillary and nasal bones (Ojala-Barbour et al. 2013). The incisive foramen is slightly hooked at the margins (Ojala-Barbour et al. 2013). *Caenolestes caniventer* is very similar to *C. sangay*, however, the two species can be distinguished by the presence of a dark pectoral spot in *C. caniventer* (Ojala-Barbour et al. 2013; Patterson 2015). Furthermore, *C. sangay* is found on the eastern slope of the Andes whereas *C. caniventer* is found on the western slope of the Andes.

Remarks. This specimen represents an elevation record at 3,572 m for the species. The previous record was 3,420 m (Tirira 2017).

RODENTIA
Family Cricetidae

***Akodon mollis* Thomas, 1894**

Material captured. Twenty-two females (one with two embryos), 30 males and 2 sex unknowns (QCAZ 17852-17906), measurements (in mm): total 131–208, ear 13–18,

Figure 2. Mammals of Quimsacocha National Recreation Area, Azuay Province, Ecuador. **A.** *Caenolestes caniventer.* **B.** *Didelphis pernigra.* **C.** *Cryptotis montivagus.* **D.** *Akodon mollis.* **E.** *Microryzomys latissimus.* **F.** *Phyllotis haggard.* **G.** *Sigmodon inopinatus.* **H.** *Coendou rufescens.* **I.** *Odocoileus virginianus ustus.* **J.** *Sylvilagus andinus.*

foot 19–26; 03°03′43″S, 079°13′54″W; elevation 3,860–3,760 m; 26 July–8 August 2018; collectors: Lee, Tinoco and Crockett. These specimens were collected in herbaceous paramo stream and patch forest in Sherman traps.

Identification. The dorsum is brownish and variable in color with some specimens more grayish in appearance (Fig. 2D). Tail length 55–92 mm (Pardiñas et al. 2017). The interorbital region of the skull is broader than the rostrum, and these specimens have carotid circulation pattern one. These characters conform to published descriptions (Pardiñas et al. 2015, 2017).

Microryzomys altissimus (Osgood, 1933)

Material captured. Four females and 19 males (QCAZ 17907–17919), measurements (in mm): total 174–202, ear 13–17, foot 19–25; 03°03′43″S, 079°13′54″W; 3,860–3,760 m; 26, 31 July; 2–5, 7 August 2018; collectors: Lee, Tinoco and Crockett. These specimens were collected in herbaceous paramo stream and patch forest in Sherman traps.

Identification. These specimens are brownish dorsally with a grayish grizzled head (Fig. 2E). The tail is bicolored and less than 142 percent of head and body length, that is indicative of *M. altissimus* (Carleton and Musser 1989). The hands and feet are whitish. The incisor tubercle on the dentary is short and indistinct and the length of maxillary toothrow is greater than 3 mm. The incisive foramina are long, penetrating M1 (Carleton 2015). *Microryzomys minutus* has a unicolored tail greater than 145 percent of head and body length. The incisor tubercle on the dentary is distinct and large, the length of maxillary toothrow is less than 3 mm, and the incisive foramina do not penetrate M1.

Phyllotis haggardi Thomas, 1908

Material captured. Five females and 5 males (QCAZ 17920-17929), measurements (in mm): total 145–209, ear 17–25, foot 21–28; 03°03′15″S, 079°13′41″W; elevation 3,850 m; 24, 26, 29, 30 July; 2, 7 August 2018; collectors: Lee, Tinoco and Crockett. These specimens were collected in herbaceous paramo in Sherman traps.

Identification. The dorsal fur is grayish with a broad dark midline. The ventral fur is white and distinctly contrasts with the dorsum (Fig. 2F). The ears are large and brownish in color. The feet are white. The bicolored tail is shorter than the head and body. The tail length in our specimens was less than 95 mm, which helps distinguish this species from sympatric *P. andium* (Pardiñas et al. 2017; Tirira 2017).

Sigmodon inopinatus Anthony, 1924

Material captured. One male (QCAZ 17930), measurements (in mm): total 222, ear 22, foot 30; 03°03′37″S, 079° 13′40″W; elevation 3,807 m; 9 August 2018; collectors: Lee, Tinoco and Crockett collected this specimen in a paramo bog. Two skulls (QCAZ 1940-41) were found in owl pellets in a paramo cliff face (03°03′32″S, 079°13′06″W); 3 August 2018.

Identification. The dorsum is orange brown and washed with black. The base of the dorsal fur is dark gray (Fig. 2G). The ventral fur is light gray (Tirira 2017). Short nasals, long incisive foramina, small auditory bullae and a narrow interorbital region distinguish this species from other *Sigmodon* (Voss 2015a).

Family Erethizontidae

***Coendou rufescens* (Gray, 1865)**

Material examined. A photographic observation was made of one individual (of unknown sex); 03°03′40″S, 079°13′55″W; elevation 3,797 m; 8 August 2018; Lee, Tinoco and Crockett observed this specimen in herbaceous paramo.

Identification. The spines on the dorsum are tricolor, rusty at the tip with black in the middle and white at the base (Voss 2015b). The quills on the rump and the base of tail are bicolored. The cheeks have a white patch (Fig. 2H). The tail is about 40% of the head and body (Barthelmess 2016).

Remarks. The photo of this specimen represents an elevation record above 3,700 m. The previous record was 3,200 m (Tirira 2017).

Lagomorpha
Family Leporidae

***Sylvilagus andinus* (Thomas, 1897)**

Material captured. One female with two embryos (QCAZ 17947), measurements (in mm): total 370, ear 51, foot 82; 03°05′20″S, 079°13′40″W; elevation 3,685 m; 6 August 2018; collectors: Lee, Tinoco and Crockett caught this specimen in herbaceous paramo with nonnative pines; this specimen was caught in a Tomahawk trap.

Identification. This specimen conforms most closely to *S. andinus*. The dorsal fur is dark brown (Fig. 2J). In contrast to *S. brasiliensis,* our specimen has a premolar foramen (Ruedas et al. 2019).

Eulipotyphla
Family Soricidae

***Cryptotis montivagus* (Anthony, 1921)**

Material captured. Two animals, sex unknown (QCAZ 17948-49), measurements (in mm): total 94–113, ear 0, foot 15–17; 03°03′43″S, 079°13′54″W; elevation 3,740 m; 7 and 8 August 2018; collectors: Lee, Tinoco and Crockett caught these specimens near a paramo steam; collected in a pitfall trap and a Sherman trap. Skulls found in owl pellets in a paramo cliff face, 03°03′32″S, 079°13′06″W, elevation 3,762 m; 3 August 2018; QCAZ 17950-71.

Identification. Our specimens have silver/gray pelage, typical of this species (Burgin and He 2018). The head and body lengths were 65 and 78 mm (Fig. 2C). We performed a phylogenetic reconstruction amplifying the Cytb gene of samples QCAZ 17948 and 17949 clustered with other samples of *C. montivagus* (GENBANK Numbers: MT179301, MT179302, MT179303) (Fig. 3). Recent discoveries of new species of *Cryptotis* in the northern Andes of South America made checking our morphological identifications with mtDNA analysis of this species imperative (Zeballos et al. 2018).

Artiodactyla
Family Cervidae

***Odocoileus virginianus* (Zimmermann, 1780)**

Material examined. Two males were observed; 03°05′34″S, 079°13′40″W; elevation 3,572 m; 23 July 2018; Lee, Tinoco and Crockett observed these specimens; pine forest.

Identification. All the major points of the antlers are directly connected to the main beam. The tail is dark brown on the dorsum and white ventrally. The dorsal and ventral fur is brownish. There is a white ring around the muzzle consistent with published descriptions (Mattioli 2011). The antlers of all the bucks we photographed in July and August were in velvet (Fig. 2I).

Discussion

To our knowledge, no study has been published on the mammalian biodiversity of Quimsacocha that saved vouchers and documented their habitat and location. The purpose of the survey was to compare different ecosystems mammalian fauna as part of a broad survey effort in the Andes of Ecuador. All previous comparable studies were conducted in July and August for a period of 3–4

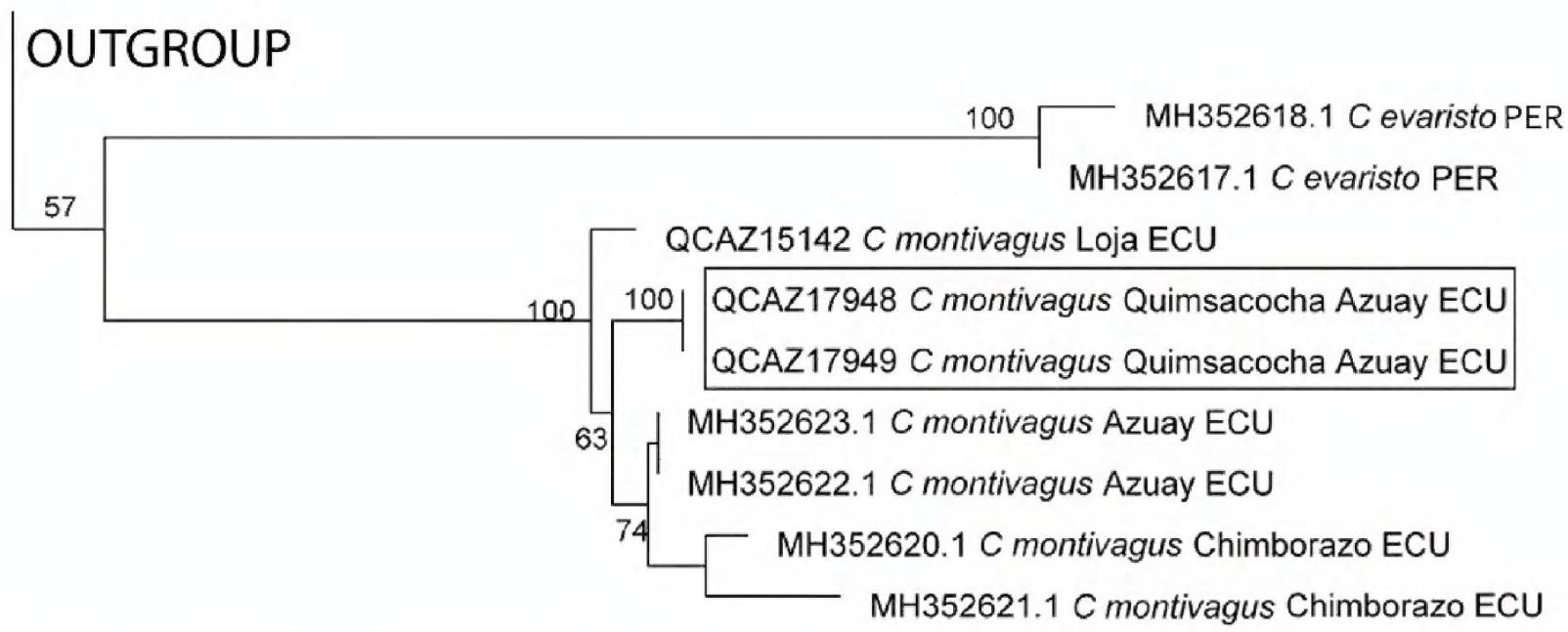

Figure 3. Phylogenetic reconstruction of *Cryptotis* based on maximum likelihood of Cytb. The box highlights the two specimens examined in this study.

Table 1. These are the GenBank sequences access numbers used to construct the Cytb tree.

GenBank number	Museum catalog number	Species
MT179301	QCAZ15142	*Cryptotis montivagus*
MT179302	QCAZ17948	*Cryptotis montivagus*
MT179303	QCAZ17949	*Cryptotis montivagus*
MH352623	QCAZ4997	*Cryptotis montivagus*
MH352622	QCAZ4996	*Cryptotis montivagus*
MH252620	QCAZ8409	*Cryptotis montivagus*
MH252621	QCAZ12037	*Cryptotis montivagus*
MH352618	MUSA7427	*Cryptotis evaristo*

weeks (Lee et al. 2006a, 2006b, 2008, 2010, 2011, 2015, 2018; Fig. 1). This survey of Quimsacocha was unlike many other similar studies that have been conducted in the paramo of the Andes. For example, one genus that was noticeably absent from our sample was *Thomasomys* Coues 1884. In previous studies with increasing elevation, the population number and diversity of *Thomasomys* increased and therefore cricetid diversity increased (Lee et al. 2018). There were similarities to recently surveyed paramo sites. For example, *Akodon mollis* and *Microryzomys altissimus* were common at both Yacuri National Park and Quimsacocha (Lee et al. 2018; Fig. 1). However, past studies also reveal that species can be common in one sample and nonexistent in another taken at a different time in the same location (Lee et al. 2015). This is why it is important to survey the same area multiple times.

Compared to other sites in the Andes, Quimsacocha has a lower diversity of mammals (Lee et al. 2018; Fig. 1). First, there were no bats recorded even though we used mist nets. Second, the habitat was predominately paramo with very few small patches of forests. Third, this was the highest elevation location of recent surveys (Lee et al. 2018). The environmental conditions were strong winds and low temperatures (–1 to 15° C). We may have surveyed an elevation where the environmental conditions are harsh enough to deter most species of plant and animal from inhabiting this ecosystem. Furthermore, in comparison to other sites (Fig. 1), the paramo at Quimsacocha has little vegetation structure to promote ecological niche diversity, which in turn would support greater cricetid diversity.

The importance of this survey is to give future researchers a baseline for further surveys and to aid in the conservation of the fauna of Quimsacocha National Recreation Area. The discovery of *Sigmodon inopinatus*, an endangered species endemic to Ecuador only previously known from Cajas and Chimborazo, relates to the importance of Quimsacocha as a refuge. To emphasize the importance of this large area of remaining paramo we noted the presence of Andean condor (*Vultur gryphus*) in the park. There is human pressure on the park from grazing livestock, mining, and introduced species such as non-native pines. These pressures will require future monitoring in order to maintain this valuable ecosystem.

Acknowledgements

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Authors' Contributions

TL received the funding to conduct the research. TL, NT, and SC collected the specimens in the field. AC and SB secured the license for field collection of specimens and other logistical help for the field trip to Quimsacocha. All authors contributed to the writing of this manuscript.

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